

In the Claims:

Please amend the claims as follows:

- 1 1. (Cancelled) An apparatus for testing functionality, evaluating performance
2 and measuring capacitance of a photo-conversion device of at least one
3 active pixel sensor of an array of active pixel sensors comprising a column
4 bus, a signal conditioning and readout circuit and a chain of circuitry
5 connected to said active pixel sensors comprising:

6 a test voltage selection circuit for selectively applying any of a plurality of voltage
7 levels that vary incrementally from a first voltage level to a second voltage
8 level to a reference distribution node of the active pixel sensors; and

9 a timing control circuit connected to the test voltage means, to said array
10 of active pixel sensors, and to a signal conditioning and readout circuit
11 to provide signals to select timings to select application of the first
12 voltage level and the second voltage level to the reference distribution
13 node of said active pixel sensors, signals at appropriate timings to
14 condition said active pixel sensors in preparation for sensing light
15 impinging upon said array of active pixel sensors, and providing
16 signals for timing said signal conditioning and readout circuit to sense
17 a signal from each active pixel sensor indicating a magnitude of light
18 impinging upon said array of active pixel sensors.

1 2. (Cancelled) The apparatus of claim 1 wherein said test voltage selection
2 circuit comprises:

3 a first switch having a first terminal connected to a first voltage source that
4 provides said first voltage level, a second terminal connected to the
5 reference distribution node of at least one active pixel sensor on a row
6 of active pixel sensors, and a control terminal connected to the
7 controlling means to selectively connect and disconnect the first
8 terminal with the second terminal;

9 a second switch having a first terminal connected to a second voltage
10 source that provides said second voltage level, a second terminal
11 connected to the reference distribution node of at least one active pixel
12 sensor on the row of active pixel sensors in the array of active pixel
13 sensors, and a control terminal connected to the controlling means to
14 selectively connect and disconnect the first terminal with the second
15 terminal; and

16 a current measuring device connected so as to measure a current flowing
17 from said first voltage source.

1 3. (Cancelled) The apparatus of claim 1 wherein the timing control circuit
2 enables measurement of the capacitance of the photo-conversion device
3 within one active pixel sensor by the steps of:

4 at a first time, selecting said active pixel sensor;

5 at a second time, placing the second voltage level at the reference

6 distribution node of said active pixel sensor;

7 simultaneously, at the second time, coupling said second voltage level to

8 the photo-conversion device;

9 at a third time, applying the first voltage level to the reference distribution

10 node;

11 simultaneously, at the third time, coupling said first voltage level to said

12 photo-conversion device;

13 measuring a current flowing to said photo-conversion device to charge the

14 capacitance of the photo-conversion device, whereby said capacitance

15 is determined by the formula:

$$C_{FD} = \frac{I}{dV/dt}$$

17 where

18 C_{FD} is the total capacitance of the photo-

19 conversion devices and the parasitic

20 capacitance of said test voltage select means,

21 I is the current flowing from said first voltage
22 source,

23 dv is the difference between the first voltage
24 level and the second voltage level, and

25 dt is a charging time for said capacitance;

1 4. (Cancelled) The apparatus of claim 1 wherein the timing control circuit
2 enables testing functionality of a row of said active pixel sensors within the
3 array of active pixel sensors and the chain of circuitry connecting said
4 selected row of active pixel sensors by the steps of:

5 at a first time, selecting said row of active pixel sensors;

6 at a second time, placing one of the plurality of voltage levels on each
7 reference distribution node of each active pixel sensor, whereby a
8 magnitude of said voltage level placed on each reference distribution
9 node is indicative of a position on said row of active pixel sensors of
10 each active pixel sensor;

11 simultaneously, at the second time, coupling the voltage level of the
12 plurality of voltage levels to the photo-conversion device to charge the
13 capacitance of the photo-conversion device to the voltage level;

14 at a third time, sampling and holding the voltage level of the capacitance
15 of each active pixel sensor on the selected row of active pixel sensors
16 within the signal conditioning and readout circuit;

17 at a fourth time, placing the first voltage level at the reference distribution
18 node of each active pixel sensor on the row of active pixel sensors;

19 simultaneously, at the fourth time, coupling said first voltage level to the
20 capacitance of the photo-conversion device of each active pixel sensor
21 of the row of active pixel sensors;

22 at a fifth time, sampling and holding the first voltage level on the
23 capacitance of the photo-conversion device of each active pixel sensor
24 on the selected row of active pixel sensors within the signal
25 conditioning and readout circuit;

26 placing the sampled and held voltage level of the plurality of voltage levels
27 and the sampled and held first voltage level of each active pixel sensor
28 of the selected row of active pixel sensors at an output port of the
29 signal conditioning and readout circuit for transfer to external circuitry,
30 whereby the external circuitry differentially compares the sampled and
31 held voltage level of the plurality of voltage levels with the sampled and
32 held first voltage level and the functionality of each active pixel sensor
33 on the selected row of active pixel sensors, and the chain of circuitry
34 connected to each active pixel sensor of the row of active pixel sensors

35 is determined as a function of a difference between the sampled and
36 held voltage level of the plurality of voltage levels and the sampled and
37 held first voltage level.

1 5. (Cancelled) The apparatus of claim 1 wherein the timing control circuit
2 enables evaluating performance of at least one active pixel sensor and the
3 chain of circuitry connected to said active pixel sensor by the steps of:
4 at a first time, selecting the active pixel sensor;
5 at a second time, placing the second voltage level at the reference
6 distribution node of the active pixel sensor;
7 simultaneously, at the second time, coupling said second voltage level to
8 the capacitance of said photo-conversion device;
9 at a third time, sampling and holding the second voltage level within the
10 signal conditioning and readout circuit;
11 at a fourth time, placing the first voltage level at the reference distribution
12 node of said active pixel sensor;
13 simultaneously, at the fourth time, coupling said first voltage level to the
14 capacitance of the photo-conversion device;

15 at a fifth time, sampling and holding the first voltage level from said
16 capacitance of said photo-conversion device of said active pixel sensor
17 to the signal conditioning and readout circuit; and

18 placing the sampled and held first voltage level and the sampled and held
19 second voltage level at an output of the signal conditioning and
20 readout circuit for transfer to external circuitry, whereby the external
21 circuitry differentially compares the sampled and held first voltage level
22 and the sampled and held second voltage level such that the
23 difference of the sampled and held first voltage level and the sampled
24 and held second voltage level determines performance of the active
25 pixel sensor.

1 6. (Cancelled) The apparatus of claim 1 wherein the test voltage selection
2 circuit comprises:

3 a first voltage distribution line containing a first distribution voltage level;

4 a second voltage distribution line containing a second distribution voltage
5 level;

6 a first switch having a first terminal connected to a first voltage source that
7 provides the first voltage level, a second terminal connected to the first
8 voltage distribution line, a third terminal connected to the second
9 voltage distribution line, and a control terminal connected to the timing

10 and control means to selectively connect the first terminal to the
11 second and third terminals concurrently;

12 a second switch having a first terminal connected to a second voltage
13 source that provides the second voltage level, a second terminal
14 connected to the first voltage distribution line, a third terminal
15 connected to the second voltage distribution line, and a control
16 terminal connected to the timing and control means to selectively
17 connect the first terminal to the second and third terminals
18 concurrently;

19 a third switch having a first terminal connected to the first voltage source,
20 a second terminal connected to the second voltage source, a third
21 terminal connected to the first voltage distribution line, a fourth terminal
22 connected to the second voltage distribution line, and a control
23 terminal connected to the timing and control means to selectively
24 connect the first terminal to the third terminal and concurrently connect
25 the second terminal to the fourth terminal;

26 a voltage dividing means connected between the first voltage distribution
27 line, and connected to the reference distribution node of each active
28 pixel sensor on a row of active pixel sensors for the array of active
29 pixel sensors for distributing an incremental voltage level that varies
30 fractionally from the first distributed voltage level present at the first

31 voltage distribution line to the second distributed voltage level present
32 at the second voltage distribution line; and

33 a current measuring means connected so as to measure current flowing
34 from said first voltage source.

1 7. (Cancelled) The apparatus of claim 5 wherein the timing control circuit
2 enables measurement of the capacitance of the photo-conversion device
3 within a group of active pixel sensors of the array of active pixel sensors
4 by the steps of:

5 at a first time, selecting said group of active pixel sensors;

6 during a period of time between a second time and a third time, activating
7 said second switch to connect the first terminal of the second switch to
8 connect the second terminal and third terminal of said second switch to
9 apply the second voltage level to the first and second voltage
10 distribution lines and thus to the reference distribution node of each
11 active pixel sensor of the group of active pixel sensors;

12 simultaneously, during the period between said second time and said third
13 time, coupling said second voltage level to the capacitance of the
14 photo-conversion device of each active pixel sensor of the group of
15 active pixel sensors to charge said capacitance to said second voltage
16 level;

17 during a period of time between a fourth time and a fifth time, activating
18 said first switch to connect the first terminal of said first switch
19 concurrently to the second and third terminals of said first switch to
20 apply the first voltage level to the first and second voltage distribution
21 lines and thus to the reference distribution node of each active pixel
22 sensor of the group of active pixel sensors;

23 simultaneously, during the period between the fourth and fifth time,
24 coupling said first voltage level to the capacitance of the photo-
25 conversion device of each active pixel sensor of the group of active
26 pixel sensors to charge said capacitance of said photo-conversion
27 device to the first voltage level;

28 measuring a current flowing from said first voltage source to charge the
29 capacitance of the photo-conversion device of each active pixel sensor
30 of the group of active pixel sensors, whereby a total capacitance of the
31 photo-conversion devices of the group of active pixel sensors and a
32 parasitic capacitance of said test voltage select means is determined
33 by the formula:

34
$$C_T = \frac{I_T}{dV/dt_{CT}}$$

35 where

36 C_T is the total capacitance of the photo-
37 conversion devices and the parasitic
38 capacitance of said test voltage select means,
39 I_T is the current flowing from said first voltage
40 source,
41 dV is the difference between the first voltage
42 level and the second voltage level, and
43 dt_{CT} is a charging time for the total
44 capacitance;
45 during a period of time between a sixth time and a seventh time, activating
46 said second switch to connect the first terminal of the second switch to
47 connect the second terminal and third terminal of said second switch to
48 apply the second voltage level to the first and second voltage
49 distribution lines and thus to the reference distribution node of each
50 active pixel sensor of the group of active pixel sensors;
51 during a period of time between an eighth time and a ninth time,
52 activating said first switch to connect the first terminal of said
53 first switch concurrently to the second and third terminals of said
54 first switch to apply the first voltage level to the first and second
55 voltage distribution lines and thus to the reference distribution

56 node of each active pixel sensor of the group of active pixel
57 sensors;

58 measuring a current flowing from said first voltage source to charge the
59 parasitic capacitance of said test voltage select means is determined
60 by the formula:

61
$$C_P = \frac{I_P}{dV/dt_{CP}}$$

62 where

63 C_P is the parasitic capacitance of said
64 test voltage select means,

65 I_P is the current flowing to the parasitic
66 capacitance C_P during charging
67 from the second voltage level to
68 the first voltage level,

69 dV is a difference between the first voltage
70 level and the second voltage level, and

71 dt_{CP} is a charging time for the parasitic
72 capacitance,

such that an average capacitance of the photo-conversion device of
each of said active pixel sensors of said group of active pixel
sensors is determined by the formula:

$$\overline{C_{FD}} = \frac{C_T - C_P}{n}$$

where

$\overline{C_{FD}}$ is the average capacitance of the
photodiode,

C_T is the total capacitance,

C_P is the parasitic capacitance, and

n is a number of active pixel sensors of the
group of active pixel sensors.

8. (Cancelled) The apparatus of claim 6 wherein the timing control circuit
enables testing functionality of a group of at least one active pixel sensor
by the steps of:
- at a first time, selecting said group of active pixel sensors;
- during a period of time between a second time and a third time, activating
said third switch to apply said first voltage level to said first voltage

7 distribution line and to apply said second voltage level to said second
8 voltage distribution line such that one of the incremental voltage levels
9 is applied to the reference distribution node of each active pixel sensor
10 of the group of active pixel sensors;

11 simultaneously, during the period between the second and third time,
12 coupling said incremental voltage level to the capacitance of the photo-
13 conversion device of each active pixel sensor to the row of active pixel
14 sensors to charge said capacitance of the photo-conversion device to
15 the incremental voltage level;

16 during a period of time between a fourth time and a fifth time, sampling
17 and holding within the signal conditioning and readout circuit the
18 incremental voltage level present on the capacitance of the photo-
19 conversion device of each of the active pixel sensors of the group of
20 active pixel sensors;

21 during a period of time between a sixth time and a seventh time, activating
22 said first switch to apply the first voltage level to the first voltage
23 distribution line and the second voltage distribution line to place the
24 first voltage level at the reference distribution node of each active pixel
25 sensor of the group of active pixel sensors;

26 simultaneously, during the period of time between the sixth time and the
27 seventh time, coupling said first voltage level from the reference

28 distribution node to the capacitance of the photo-conversion device of
29 each active pixel sensor of the group of active pixel sensors to charge
30 said capacitance of the photo-conversion device from said incremental
31 voltage level to said first voltage level;

32 during a period of time between an eighth time and a ninth time, sampling
33 and holding within the signal conditioning and readout circuit said first
34 voltage level present on said capacitance of said photo-conversion
35 device of each active pixel sensor of the group of active pixel sensors;

36 placing the sampled and held incremental voltage level present of the
37 capacitance of the photo-conversion device of each of the active pixel
38 sensors of the group of active pixel sensors and the sampled and held
39 first voltage level of each of the active pixel sensors of the group of
40 active pixel sensors at an output port of the signal conditioning and
41 readout circuit for transfer to external circuitry, whereby the external
42 circuitry differentially compares said sampled and held incremental
43 voltage level and said first voltage level, thus determining the
44 functionality of each active pixel sensor of the group of active pixel
45 sensors, and the chain of circuitry connected to each active pixel
46 sensor of the group of active pixel sensors is determined as a function
47 of a difference between the sampled and held incremental voltage
48 level and the sampled and held first voltage level.

1 9. (Cancelled) The apparatus of claim 6 wherein the timing control circuit
2 enables evaluating performance of a group of at least one active pixel
3 sensor of the array of active pixel sensors by the steps of:
4 at a first time, selecting said group of active pixel sensors;
5 during a period of time between a second time and a third time, activating
6 said second switch to apply said second voltage level to said voltage
7 distribution line such that said second voltage level is applied to the
8 reference distribution node of each active pixel sensor of the group of
9 active pixel sensors;
10 simultaneously, during the period of time between the second and third
11 time, coupling said second voltage level to the capacitance of the
12 photo-conversion device of each active pixel sensor to the row of
13 active pixel sensors to charge said capacitance of the photo-
14 conversion device to the second voltage level;
15 during a period of time between a fourth time and a fifth time, sampling
16 and holding within the signal conditioning and readout circuit the
17 second voltage level present on the capacitance of the photo-
18 conversion device of each of the active pixel sensors of the group of
19 active pixel sensors;

20 during a period of time between a sixth time and a seventh time, activating
21 said first switch to apply the first voltage level to the first voltage
22 distribution line and the second voltage distribution line to place the
23 first voltage level at the reference distribution node of each active pixel
24 sensor of the group of active pixel sensors;

25 simultaneously, during the period of time between the sixth time and the
26 seventh time, coupling said first voltage level from the reference
27 distribution node to the capacitance of the photo-conversion device of
28 each active pixel sensor of the group of active pixel sensors to charge
29 said capacitance of the photo-conversion device from said incremental
30 voltage level to said first voltage level;

31 during a period of time between an eighth time and a ninth time, sampling
32 and holding within the signal conditioning and readout circuit said first
33 voltage level present on said capacitance of each active pixel sensor of
34 the group of active pixel sensors;

35 placing the sampled and held second voltage level present on the
36 capacitance of the photo-conversion device of each of the active pixel
37 sensors of the group of active pixel sensors and the sampled and held
38 first voltage level of each of the active pixel sensors of the group of
39 active pixel sensors at an output port of the signal conditioning and
40 readout circuit for transfer to external circuitry, whereby the external

41 circuitry differentially compares said sampled and held second voltage
42 level and said first voltage level, thus determining performance of each
43 active pixel sensor of the group of active pixel sensors and of the chain
44 of circuitry connected to each active pixel sensor of the group of active
45 pixel sensors is determined as a function of a difference between the
46 sampled and held incremental voltage level and the sampled and held
47 first voltage level.

1 10. (Cancelled) The apparatus of claim 9 wherein evaluating performance of
2 each active pixel sensor of the group of active pixel sensors includes
3 evaluating range and linearity of each active pixel sensor and the chain of
4 circuitry connected to active pixel sensor.

1 11. (Cancelled) The apparatus of claim 6 wherein the group of active pixel
2 sensors is a row of active pixel sensors placed in an area of dark pixels of
3 the array of active pixel sensors.

1 12. (Cancelled) A photo-imaging integrated circuit comprising:
2 containing said an array of active pixel sensors arranged in rows and
3 columns whereby each active pixel sensor comprises:
4 a photo-conversion device which converts light impinging upon said
5 photo-conversion device to electrons which are retained at a
6 capacitance of said photo-conversion device,

7 a reset reference means connected to said photo-conversion
8 d vice to selectively apply a reference voltage level to said
9 photo-conversion device,
10 a reference distribution node connected to the reset reference
11 means reference voltage level,
12 a source follower means connected to the photo-conversion device
13 to provide an output voltage level at an output terminal
14 approximating a voltage present on said photo-conversion
15 device, and
16 a pixel selecting means connected to the source follower means to
17 activate said source follower means to transfer the output
18 voltage level to said output terminal;
19 a test voltage selection means connected to at least one active pixel for
20 selectively applying any of a plurality of voltage levels that vary
21 incrementally from a first voltage level to a second voltage level to the
22 reference distribution node of the active pixel sensors;
23 a plurality of column bus means connected such that each column bus
24 means is connected to each output terminal of each active pixel sensor
25 of each column of active pixel sensors;

26 a plurality of signal conditioning and readout circuits, whereby each signal
27 conditioning and readout circuit is connected to each column bus
28 means to sample and hold the output voltage level at the output
29 terminal of a selected active pixel sensors of a row of active pixel
30 sensors, and in response to said output signal provide a first and
31 second sampled and held output signal; and

32 a timing and control means connected to the array of active pixel sensors,
33 the test voltage selection means and the plurality of signal conditioning
34 and readout circuits to provide timing and control signals that select
35 active pixel sensors to transfer signals to the column bus and thence to
36 the signal conditioning and readout circuits, and to provide the first and
37 second sampled and held readout signals.

1 13. (Cancelled) The photo-imaging integrated circuit of claim 12 wherein said
2 test voltage selection means comprises:

3 a first switch having a first terminal connected to a first voltage source that
4 provides said first voltage level, a second terminal connected to the
5 reference distribution node of at least one active pixel sensor on a row
6 of active pixel sensors, and a control terminal connected to the
7 controlling means to selectively connect and disconnect the first
8 terminal with the second terminal;

9 a second switch having a first terminal connected to a second voltage
10 source that provides said second voltage level, a second terminal
11 connected to the reference distribution node of at least one active pixel
12 sensor on the row of active pixel sensors in the array of active pixel
13 sensors, and a control terminal connected to the controlling means to
14 selectively connect and disconnect the first terminal with the second
15 terminal; and

16 a current measuring device connected so as to measure a current flowing
17 from said first voltage source.

18 14. (Cancelled) The photo-imaging integrated circuit of claim 12 wherein the
19 timing control means enables measurement of the capacitance of the
20 photo-conversion device within one active pixel sensor by the steps of:

21 at a first time, selecting said active pixel sensor;

22 at a second time, placing the second voltage level at the reference
23 distribution node of said active pixel sensor;

24 simultaneously, at the second time, coupling said second voltage level to
25 the photo-conversion device;

26 at a third time, applying the first voltage level to the reference distribution
27 node ;

simultaneously, at the third time, coupling said first voltage level to said photo-conversion device;

measuring a current flowing to said photo-conversion device to charge the capacitance of the photo-conversion device, whereby said capacitance is determined by the formula:

$$C_{FD} = \frac{I}{dV/dt}$$

where

C_{FD} is the total capacitance of the photo-conversion devices and the parasitic capacitance of said test voltage select means,

I is the current flowing from said first voltage source,

dV is the difference between the first voltage level and the second voltage level, and

dt is a charging time for said capacitance;

15. (Cancelled) The photo-imaging integrated circuit of claim 12 wherein the timing control means enables testing functionality of a row of said active pixel sensors within the array of active pixel sensors and the chain of

4 circuitry connecting said selected row of active pixel sensors by the steps
5 of:

6 at a first time, selecting said row of active pixel sensors;

7 at a second time, placing one of the plurality of voltage levels on each
8 reference distribution node of each active pixel sensor, whereby a
9 magnitude of said voltage level placed on each reference distribution
10 node is indicative of a position on said row of active pixel sensors of
11 each active pixel sensor;

12 simultaneously, at the second time, coupling the voltage level of the
13 plurality of voltage levels to the photo-conversion device to charge the
14 capacitance of the photo-conversion device to the voltage level;

15 at a third time, sampling and holding the voltage level of the capacitance
16 of each active pixel sensor on the selected row of active pixel sensors
17 within the signal conditioning and readout circuit;

18 at a fourth time, placing the first voltage level at the reference distribution
19 node of each active pixel sensor on the row of active pixel sensors;

20 simultaneously, at the fourth time, coupling said first voltage level to the
21 capacitance of the photo-conversion device of each active pixel sensor
22 of the row of active pixel sensors;

23 at a fifth time, sampling and holding the first voltage level on the
24 capacitance of the photo-conversion device of each active pixel sensor
25 on the selected row of active pixel sensors within the signal
26 conditioning and readout circuit;

27 placing the sampled and held voltage level of the plurality of voltage levels
28 and the sampled and held first voltage level of each active pixel sensor
29 of the selected row of active pixel sensors at an output port of the
30 signal conditioning and readout circuit for transfer to external circuitry,
31 whereby the external circuitry differentially compares the sampled and
32 held voltage level of the plurality of voltage levels with the sampled and
33 held first voltage level and the functionality of each active pixel sensor
34 on the selected row of active pixel sensors, and the chain of circuitry
35 connected to each active pixel sensor of the row of active pixel sensors
36 is determined as a function of a difference between the sampled and
37 held voltage level of the plurality of voltage levels and the sampled and
38 held first voltage level.

1 16. (Cancelled) The photo-imaging integrated circuit of claim 12 wherein the
2 timing and control means enables evaluating performance of at least one
3 active pixel sensor and the chain of circuitry connected to said active pixel
4 sensor by the steps of:
5 at a first time, selecting the active pixel sensor;

6 at a second time, placing the second voltage level at the reference
7 distribution node of the active pixel sensor;

8 simultaneously, at the second time, coupling said second voltage level to
9 the capacitance of said photo-conversion device;

10 at a third time, sampling and holding the second voltage level within the
11 signal conditioning and readout circuit;

12 at a fourth time, placing the first voltage level at the reference distribution
13 node of said active pixel sensor;

14 simultaneously, at the fourth time, coupling said first voltage level to the
15 capacitance of the photo-conversion device;

16 at a fifth time, sampling and holding the first voltage level from said
17 capacitance of said photo-conversion device of said active pixel sensor
18 to the signal conditioning and readout circuit; and

19 placing the sampled and held first voltage level and the sampled and held
20 second voltage level at an output of the signal conditioning and
21 readout circuit for transfer to external circuitry, whereby the external
22 circuitry differentially compares the sampled and held first voltage level
23 and the sampled and held second voltage level such that the
24 difference of the sampled and held first voltage level and the sampled

25 and held second voltage level determines performance of the active
26 pixel sensor.

1 17. (Cancelled) The photo-imaging integrated circuit of claim 12 wherein the
2 test voltage selection means comprises:

3 a first voltage distribution line containing a first distribution voltage level;

4 a second voltage distribution line containing a second distribution voltage
5 level;

6 a first switch having a first terminal connected to a first voltage source that
7 provides the first voltage level, a second terminal connected to the first
8 voltage distribution line, a third terminal connected to the second
9 voltage distribution line, and a control terminal connected to the timing
10 and control means to selectively connect the first terminal to the
11 second and third terminals concurrently;

12 a second switch having a first terminal connected to a second voltage
13 source that provides the second voltage level, a second terminal
14 connected to the first voltage distribution line, a third terminal
15 connected to the second voltage distribution line, and a control
16 terminal connected to the timing and control means to selectively
17 connect the first terminal to the second and third terminals
18 concurrently;

19 a third switch having a first terminal connected to the first voltage source,
20 a second terminal connected to the second voltage source, a third
21 terminal connected to the first voltage distribution line, a fourth terminal
22 connected to the second voltage distribution line, and a control
23 terminal connected to the timing and control means to selectively
24 connect the first terminal to the third terminal and concurrently connect
25 the second terminal to the fourth terminal;

26 a voltage dividing means connected between the first voltage distribution
27 line, and connected to the reference distribution node of each active
28 pixel sensor on a row of active pixel sensors for the array of active
29 pixel sensors for distributing an incremental voltage level that varies
30 fractionally from the first distributed voltage level present at the first
31 voltage distribution line to the second distributed voltage level present
32 at the second voltage distribution line; and

33 a current measuring means connected so as to measure current flowing
34 from said first voltage source.

1 18. (Cancelled) The photo-imaging integrated circuit of claim 17 wherein the
2 timing and control means enables measurement of the capacitance of the
3 photo-conversion device within a group of active pixel sensors of the array
4 of active pixel sensors by the steps of:

5 at a first time, selecting said group of active pixel sensors;

6 during a period of time between a second time and a third time, activating
7 said second switch to connect the first terminal of the second switch to
8 connect the second terminal and third terminal of said second switch to
9 apply the second voltage level to the first and second voltage
10 distribution lines and thus to the reference distribution node of each
11 active pixel sensor of the group of active pixel sensors;

12 simultaneously, during the period between said second time and said third
13 time, coupling said second voltage level to the capacitance of the
14 photo-conversion device of each active pixel sensor of the group of
15 active pixel sensors to charge said capacitance to said second voltage
16 level;

17 during a period of time between a fourth time and a fifth time, activating
18 said first switch to connect the first terminal of said first switch
19 concurrently to the second and third terminals of said first switch to
20 apply the first voltage level to the first and second voltage distribution
21 lines and thus to the reference distribution node of each active pixel
22 sensor of the group of active pixel sensors;

23 simultaneously, during the period between the fourth and fifth time,
24 coupling said first voltage level to the capacitance of the photo-
25 conversion device of each active pixel sensor of the group of active

26 pixel sensors to charge said capacitance of said photo-conversion
27 device to the first voltage level;

28 measuring a current flowing from said first voltage source to charge the
29 capacitance of the photo-conversion device of each active pixel sensor
30 of the group of active pixel sensors, whereby a total capacitance of the
31 photo-conversion devices of the group of active pixel sensors and a
32 parasitic capacitance of said test voltage select means is determined
33 by the formula:

34
$$C_T = \frac{I_T}{dV/dt_{CT}}$$

35 where

36 C_T is the total capacitance of the photo-
37 conversion devices and the parasitic
38 capacitance of said test voltage select means,

39 I_T is the current flowing from said first voltage
40 source,

41 dV is the difference between the first voltage
42 level and the second voltage level, and

43 dt_{CT} is a charging time for the total
44 capacitance;

45 during a period of time between a sixth time and a seventh time, activating
46 said second switch to connect the first terminal of the second switch to
47 connect the second terminal and third terminal of said second switch to
48 apply the second voltage level to the first and second voltage
49 distribution lines and thus to the reference distribution node of each
50 active pixel sensor of the group of active pixel sensors;

51 during a period of time between an eighth time and a ninth time, activating
52 said first switch to connect the first terminal of said first switch
53 concurrently to the second and third terminals of said first switch to
54 apply the first voltage level to the first and second voltage distribution
55 lines and thus to the reference distribution node of each active pixel
56 sensor of the group of active pixel sensors;

57 measuring a current flowing from said first voltage source to charge the
58 parasitic capacitance of said test voltage select means is determined
59 by the formula:

60
$$C_P = \frac{I_P}{dV / dt_{CP}}$$

61 where

62 C_P is the parasitic capacitance of said
63 test voltage select means,

64 I_P is the current flowing to the parasitic
65 capacitance C_P during charging
66 from the second voltage level to
67 the first voltage level,

68 dv is a difference between the first voltage
69 level and the second voltage level, and

70 dt_{CP} is a charging time for the parasitic
71 capacitance,

72 such that an average capacitance of the photo-conversion device of
73 each of said active pixel sensors of said group of active pixel
74 sensors is determined by the formula:

75
$$\overline{C_{FD}} = \frac{C_T - C_P}{n}$$

76 where

77 $\overline{C_{FD}}$ is the average capacitance of the
78 photodiode,

79 C_T is the total capacitance,

80 C_p is the parasitic capacitance, and
81 n is a number of active pixel sensors of the
82 group of active pixel sensors.

1 19. (Cancelled) The photo-imaging integrated circuit of claim 17 wherein the
2 timing and control means enables testing functionality of a group of at
3 least one active pixel sensor by the steps of:

4 at a first time, selecting said group of active pixel sensors;

5 during a period of time between a second time and a third time, activating
6 said third switch to apply said first voltage level to said first voltage
7 distribution line and to apply said second voltage level to said second
8 voltage distribution line such that one of the incremental voltage levels
9 is applied to the reference distribution node of each active pixel sensor
10 of the group of active pixel sensors;

11 simultaneously, during the period between the second and third time,
12 coupling said incremental voltage level to the capacitance of the photo-
13 conversion device of each active pixel sensor to the row of active pixel
14 sensors to charge said capacitance of the photo-conversion device to
15 the incremental voltage level;

16 during a period of time between a fourth time and a fifth time, sampling
17 and holding within the signal conditioning and readout circuit the

18 incremental voltage level present on the capacitance of the photo-
19 conversion device of each of the active pixel sensors of the group of
20 active pixel sensors;

21 during a period of time between a sixth time and a seventh time, activating
22 said first switch to apply the first voltage level to the first voltage
23 distribution line and the second voltage distribution line to place the
24 first voltage level at the reference distribution node of each active pixel
25 sensor of the group of active pixel sensors;

26 simultaneously, during the period of time between the sixth time and the
27 seventh time, coupling said first voltage level from the reference
28 distribution node to the capacitance of the photo-conversion device of
29 each active pixel sensor of the group of active pixel sensors to charge
30 said capacitance of the photo-conversion device from said incremental
31 voltage level to said first voltage level;

32 during a period of time between an eighth time and a ninth time, sampling
33 and holding within the signal conditioning and readout circuit said first
34 voltage level present on said capacitance of said photo-conversion
35 device of each active pixel sensor of the group of active pixel sensors;

36 placing the sampled and held incremental voltage level present of the
37 capacitance of the photo-conversion device of each of the active pixel
38 sensors of the group of active pixel sensors and the sampled and held

39 first voltage level of each of the active pixel sensors of the group of
40 active pixel sensors at an output port of the signal conditioning and
41 readout circuit for transfer to external circuitry, whereby the external
42 circuitry differentially compares said sampled and held increment
43 voltage level and said first voltage level, thus determining the
44 functionality of each active pixel sensor of the group of active pixel
45 sensors, and the chain of circuitry connected to each active pixel
46 sensor of the group of active pixel sensors is determined as a function
47 of a difference between the sampled and held incremental voltage
48 level and the sampled and held first voltage level.

1 20. (Cancelled) The photo-imaging integrated circuit of claim 17 wherein the
2 timing and control means enables evaluating performance of a group of at
3 least one active pixel sensor of the array of active pixel sensors by the
4 steps of:

5 at a first time, selecting said group of active pixel sensors;

6 during a period of time between a second time and a third time, activating
7 said second switch to apply said second voltage level to said voltage
8 distribution line such that said second voltage level is applied to the
9 reference distribution node of each active pixel sensor of the group of
10 active pixel sensors;

11 simultaneously, during the period of time between the second and third
12 time, coupling said second voltage level to the capacitance of the
13 photo-conversion device of each active pixel sensor to the row of
14 active pixel sensors to charge said capacitance of the photo-
15 conversion device to the second voltage level;

16 during a period of time between a fourth time and a fifth time, sampling
17 and holding within the signal conditioning and readout circuit the
18 second voltage level present on the capacitance of the photo-
19 conversion device of each of the active pixel sensors of the group of
20 active pixel sensors;

21 during a period of time between a sixth time and a seventh time, activating
22 said first switch to apply the first voltage level to the first voltage
23 distribution line and the second voltage distribution line to place the
24 first voltage level at the reference distribution node of each active pixel
25 sensor of the group of active pixel sensors;

26 simultaneously, during the period of time between the sixth time and the
27 seventh time, coupling said first voltage level from the reference
28 distribution node to the capacitance of the photo-conversion device of
29 each active pixel sensor of the group of active pixel sensors to charge
30 said capacitance of the photo-conversion device from said incremental
31 voltage level to said first voltage level;

32 during a period of time between an eighth time and a ninth time, sampling
33 and holding within the signal conditioning and readout circuit said first
34 voltage level present on said capacitance of each active pixel sensor of
35 the group of active pixel sensors;

36 placing the sampled and held second voltage level present on the
37 capacitance of the photo-conversion device of each of the active pixel
38 sensors of the group of active pixel sensors and the sampled and held
39 first voltage level of each of the active pixel sensors of the group of
40 active pixel sensors at an output port of the signal conditioning and
41 readout circuit for transfer to external circuitry, whereby the external
42 circuitry differentially compares said sampled and held second voltage
43 level and said first voltage level, thus determining performance of each
44 active pixel sensor of the group of active pixel sensors and of the chain
45 of circuitry connected to each active pixel sensor of the group of active
46 pixel sensors is determined as a function of a difference between the
47 sampled and held incremental voltage level and the sampled and held
48 first voltage level.

1 21. (Cancelled) The photo-imaging integrated circuit of claim 20 wherein
2 evaluating performance of each active pixel sensor of the group of active
3 pixel sensors includes evaluating range and linearity of each active pixel
4 sensor and the chain of circuitry connected to active pixel sensor.

- 1 22. (Cancelled) The photo-imaging integrated circuit of claim 20 wherein the
2 group of active pixel sensors is a row of active pixel sensors placed in an
3 area of dark pixels of the array of active pixel sensors.
- 1 23. (Original) A method for verifying operation of a group of at least one active
2 pixel sensor within an array of active pixel sensors and of a chain of
3 circuitry connected to each active pixel sensor for capturing an output
4 signal from said active pixel sensor, whereby said chain of circuitry
5 includes a column bus circuit and a signal conditioning and readout circuit,
6 and whereby said method comprises the step of:
7 testing functionality of said group of active pixel sensors and the chain of
8 circuitry connected to each active pixel sensor of the group of active
9 pixel sensors by the steps of:
10 activating said group of active pixel sensors,
11 applying one of a group of voltage levels that vary incrementally
12 from a first voltage level to charge a capacitance of a photo-
13 conversion device of each active pixel sensor of the group of
14 active pixel sensors to a first charging voltage level and
15 sampling and holding said first charging voltage level from the
16 capacitance of the photo-conversion device of each active pixel
17 sensor of the group of active pixel sensors,

18 applying the first voltage level to charge the capacitance of the
19 photo-conversion device of each active pixel sensor of the
20 group of active pixel sensors to a second charging voltage level,
21 sampling and holding a second charging voltage level from said
22 capacitance of the photo-conversion device of each active pixel
23 sensor of the group of active pixel sensors,
24 differentially comparing the first charging voltage level with the
25 second charging voltage level to create a first difference
26 voltage, whereby said first difference voltage indicates the
27 functionality of each active pixel sensor of the group of active
28 pixel sensors and the chain of circuitry connected to said active
29 pixel sensor.

1 24. (Cancelled) A method for verifying operation of a group of at least one
2 active pixel sensor within an array of active pixel sensors and of a chain of
3 circuitry connected to each active pixel sensor for capturing an output
4 signal from said active pixel sensor, whereby said chain of circuitry
5 includes a column bus circuit and a signal conditioning and readout circuit,
6 and whereby said method comprises the step of:

7 evaluating performance of said group of active pixel sensors and the chain
8 of circuitry connected to each active pixel sensor of the group of active
9 pixel sensors by the steps of:

10 activating said group of active pixel sensors ,

11 applying the second voltage level to charge a capacitance of a

12 photo-conversion device of each active pixel sensor of the

13 group of active pixel sensors to a third charging voltage level,

14 sampling and holding the third charging voltage level from said

15 capacitance of the photo-conversion device of each active pixel

16 sensor of the group of active pixel sensors,

17 applying the first voltage level to charge the capacitance of the

18 photo-conversion device of each active pixel sensor of the

19 group of active pixel sensors to a fourth charging voltage level,

20 sampling and holding the fourth charging voltage level from said

21 capacitance of the photo-conversion device of each active pixel

22 sensor of the group of active pixel sensors,

23 differentially comparing the third charging voltage level with the

24 fourth charging voltage level to create a second difference

25 voltage, whereby said second difference voltage indicates said

26 performance of each active pixel sensor of the group of active

27 pixel sensors and the chain of circuitry connected to said active

28 pixel sensor.

1 25. (Cancelled) A method for verifying operation of a group of at least one
2 active pixel sensor within an array of active pixel sensors and of a chain of
3 circuitry connected to each active pixel sensor for capturing an output
4 signal from said active pixel sensor, whereby said method comprises the
5 step of:
6 determining an average capacitance of a photo-conversion device of each
7 active pixel sensor of said group of active pixel sensors by the steps of:
8 applying a first voltage level to charge to a first voltage charging
9 level a total capacitance including said capacitance of said
10 photo-conversion device and a parasitic capacitance formed by
11 interconnecting circuits between a voltage source and providing
12 said first voltage level and said active pixel sensor,
13 applying a second voltage level provided by a second voltage
14 source to charge from the first charging voltage level to a
15 second charging voltage level said total capacitance,
16 measuring a current flowing into said total capacitance,
17 determining a first charging time for the first charging voltage level
18 to charge to the second charging voltage level,
19 calculating the total capacitance by the formula:

20
$$C_T = \frac{I_T}{dV/dt_{CT}}$$

21 where

22 C_T is the total capacitance of the photo-
23 conversion devices and the parasitic
24 capacitance of said test voltage select means,

25 I_T is the current flowing from said first voltage
26 source,

27 dV is the difference between the first voltage
28 level and the second voltage level, and

29 dt_{CT} is a charging time for the total
30 capacitance;

31 applying the first voltage level to the parasitic capacitance to charge
32 said parasitic capacitance to a third charging voltage level,

33 applying the second voltage level to the parasitic capacitance to
34 charge said parasitic capacitance from the third charging
35 voltage level to a fourth charging voltage level,

36 measuring a current flowing into said parasitic capacitance,

37 determining a second charging time for the third charging
38 voltage level to charge to the fourth charging voltage
39 level,

40 calculating the parasitic capacitance by the formula:

41
$$C_P = \frac{I_P}{dV/dt_{CP}}$$

42 where

43 C_P is the parasitic capacitance of said
44 test voltage select means,

45 I_P is the current flowing to the parasitic
46 capacitance C_P during charging
47 from the second voltage level to
48 the first voltage level,

49 dV is a difference between the first voltage
50 level and the second voltage level, and

51 dt_{CP} is a charging time for the parasitic
52 capacitance,

53 determining the average capacitance of the photo-conversion
54 device by the formula:

55
$$\overline{C_{FD}} = \frac{C_T - C_P}{n}$$

56 where

57 $\overline{C_{FD}}$ is the average capacitance of the
58 photodiode,

59 C_T is the total capacitance,

60 C_P is the parasitic capacitance, and

61 n is a number of active pixel sensors of the
62 group of active pixel sensors.

1 26. (Cancelled) A method for verifying operation of a group of at least one
2 active pixel sensor within an array of active pixel sensors and of a chain of
3 circuitry connected to each active pixel sensor for capturing an output
4 signal from said active pixel sensor, whereby said chain of circuitry
5 includes a column bus circuit and a signal conditioning and readout circuit,
6 and whereby said method comprises the steps of:

7 testing functionality of said group of active pixel sensors and the chain of
8 circuitry connected to each active pixel sensor of the group of active
9 pixel sensors by comparing the difference between two voltage levels
10 applied to charge a capacitance of a photo-conversion device of each

11 active pixel sensor to a first charging voltage level and a sampled and
12 held first charging voltage level, whereby an amplitude of said sampled
13 and held first charging voltage level determines the functionality of said
14 active pixel sensors and said chain of circuitry;

15 evaluating performance of said groups of active pixel sensors and the
16 chain of circuitry connected to each active pixel sensor of the group of
17 active pixel sensors by comparing the difference between a first
18 voltage level and a second voltage level applied at separate times to
19 charge the capacitance of the photo-conversion device of each active
20 pixel sensor to a second charging voltage level and a sampled and
21 held second charging voltage level, whereby an amplitude of said
22 sampled and held charging voltage level determines performance of
23 said group of active pixel sensors; and

24 determining an average capacitance of each photo-conversion device of
25 each active pixel sensor of the group of active pixel sensors by
26 charging the capacitance between the first and the second voltage
27 levels, measuring a charging current into said capacitance, measuring
28 a charging time, and calculating said capacitance.

1 27. (Cancelled) The method of claim 26 wherein testing functionality
2 comprises the steps of:
3 activating said group of active pixel sensors;

4 applying one of a group of voltage levels that vary incrementally from a
5 first voltage V_1 to charge a capacitance of a photo-conversion device
6 of each active pixel sensor of the group of active pixel sensors to a first
7 charging voltage level and sampling and holding said first charging
8 voltage level from the capacitance of the photo-conversion device of
9 each active pixel sensor of the group of active pixel sensors;

10 applying the first voltage level to charge the capacitance of the photo-
11 conversion device of each active pixel sensor of the group of active
12 pixel sensors to a second charging voltage level;

13 sampling and holding a second charging voltage level from said
14 capacitance of the photo-conversion device of each active pixel sensor
15 of the group of active pixel sensors;

16 differentially comparing the first charging voltage level with the second
17 charging voltage level to create a first difference voltage, whereby said
18 first difference voltage indicates the functionality of each active pixel
19 sensor of the group of active pixel sensors and the chain of circuitry
20 connected to said active pixel sensor.

1 28. (Cancelled) The method of claim 26 wherein evaluating performance
2 comprises the steps of:

3 activating said group of active pixel sensors ,

4 applying the second voltage level to charge a capacitance of a
5 photo-conversion device of each active pixel sensor of the
6 group of active pixel sensors to a third charging voltage level,
7 sampling and holding the third charging voltage level from said
8 capacitance of the photo-conversion device of each active pixel
9 sensor of the group of active pixel sensors,
10 applying the first voltage level to charge the capacitance of the
11 photo-conversion device of each active pixel sensor of the
12 group of active pixel sensors to a fourth charging voltage level,
13 sampling and holding the fourth charging voltage level from said
14 capacitance of the photo-conversion device of each active pixel
15 sensor of the group of active pixel sensors,
16 differentially comparing the third charging voltage level with the
17 fourth charging voltage level to create a second difference
18 voltage, whereby said second difference voltage indicates said
19 performance of each active pixel sensor of the group of active
20 pixel sensors and the chain of circuitry connected to said active
21 pixel sensor.

1 29. (Cancelled) The method of claim 26 wherein determining average
2 capacitance comprises the steps of:

3 applying a first voltage level to charge to a first voltage charging
4 level a total capacitance including said capacitance of said
5 photo-conversion device and a parasitic capacitance formed by
6 interconnecting circuits between a voltage source and providing
7 said first voltage level and said active pixel sensor,
8 applying a second voltage level provided by a second voltage
9 source to charge from the first charging voltage level to a
10 second charging voltage level said total capacitance,
11 measuring a current flowing into said total capacitance,
12 determining a first charging time for the first charging voltage level
13 to charge to the second charging voltage level,
14 calculating the total capacitance by the formula:

$$C_T = \frac{I_T}{dV/dt_{CT}}$$

16 where

17 C_T is the total capacitance of the photo-
18 conversion devices and the parasitic
19 capacitance of said test voltage select means,

20 I_T is the current flowing from said first voltage
21 source,

22 dV is the difference between the first voltage
23 level and the second voltage level, and

24 dt_{CT} is a charging time for the total
25 capacitance;

26

27 applying the first voltage level to the parasitic capacitance to charge
28 said parasitic capacitance to a third charging voltage level,

29 applying the second voltage level to the parasitic capacitance to
30 charge said parasitic capacitance from the third charging
31 voltage level to a fourth charging voltage level,

32 measuring a current flowing into said parasitic capacitance,

33 determining a second charging time for the third charging
34 voltage level to charge to the fourth charging voltage
35 level,

36 calculating the parasitic capacitance by the formula:

37
$$C_P = \frac{I_P}{dV/dt_{CP}}$$

38 where

39 C_P is the parasitic capacitance of said
40 test voltage select means,

41 I_P is the current flowing to the parasitic
42 capacitance C_P during charging
43 from the second voltage level to
44 the first voltage level,

45 dV is a difference between the first voltage
46 level and the second voltage level, and

47 dt_{CP} is a charging time for the parasitic
48 capacitance,

49

50 determining the average capacitance of the photo-conversion
51 device by the formula:

52
$$\overline{C_{FD}} = \frac{C_T - C_P}{n}$$

53 where

54 $\overline{C_{FD}}$ is the average capacitance of the
55 photodiode,
56 C_T is the total capacitance,
57 C_P is the parasitic capacitance, and
58 n is a number of active pixel sensors of the
59 group of active pixel sensors.

Please cancel Claims 1-22 and 24-29.